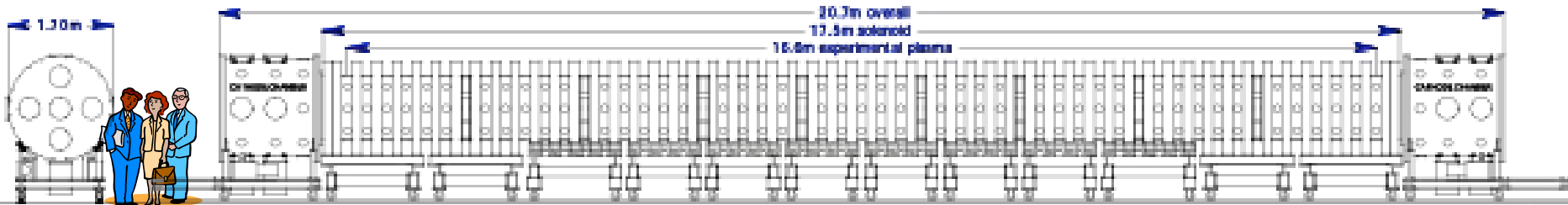


# Multiscale Turbulence excited by a pulsed current sheet

Walter Gekelman ,Stephen Vincena,  
Patrick Pribyl , Brett Jacobs, Eric Lawrence  
(UCLA Department of Physics and Astronomy),  
Paul Kintner (Cornell University,Dept. of Engineering)  
Franklin Chiang (UCLA Dept of Engineering)  
Noam Katz (Physics Dept, MIT)

# Overview of the experimental device

## The Large Plasma Device (LAPD)



**Cathode discharge plasma**

**Highly Ionized plasmas  $n \approx 3 \times 10^{12} / \text{cm}^3$**

**Reproducible, 1Hz operation**

**> 4-month cathode lifetime**

**Up to 2.5kG DC Magnetic Field on axis**

**Plasma column up to  $2000R_{ci}$  across diameter**

**Over 450 Access ports, with 50 ball joints**

**Computer Controlled Data Acquisition**

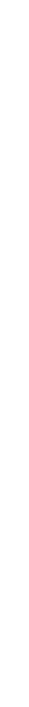
**Microwave Interferometers**

**Laser-Induced Fluorescence**

**Large variety of probes**

**Operates as a national user facility**

**<http://plasma.physics.ucla.edu/>**



# Neon Plasma

$n=2-5 \times 10^{12} / \text{cm}^3$

$B= .5-15 \text{ kG}$ , dia = 60 cm L=19 m

Oct 2001

# Electric Field Probes

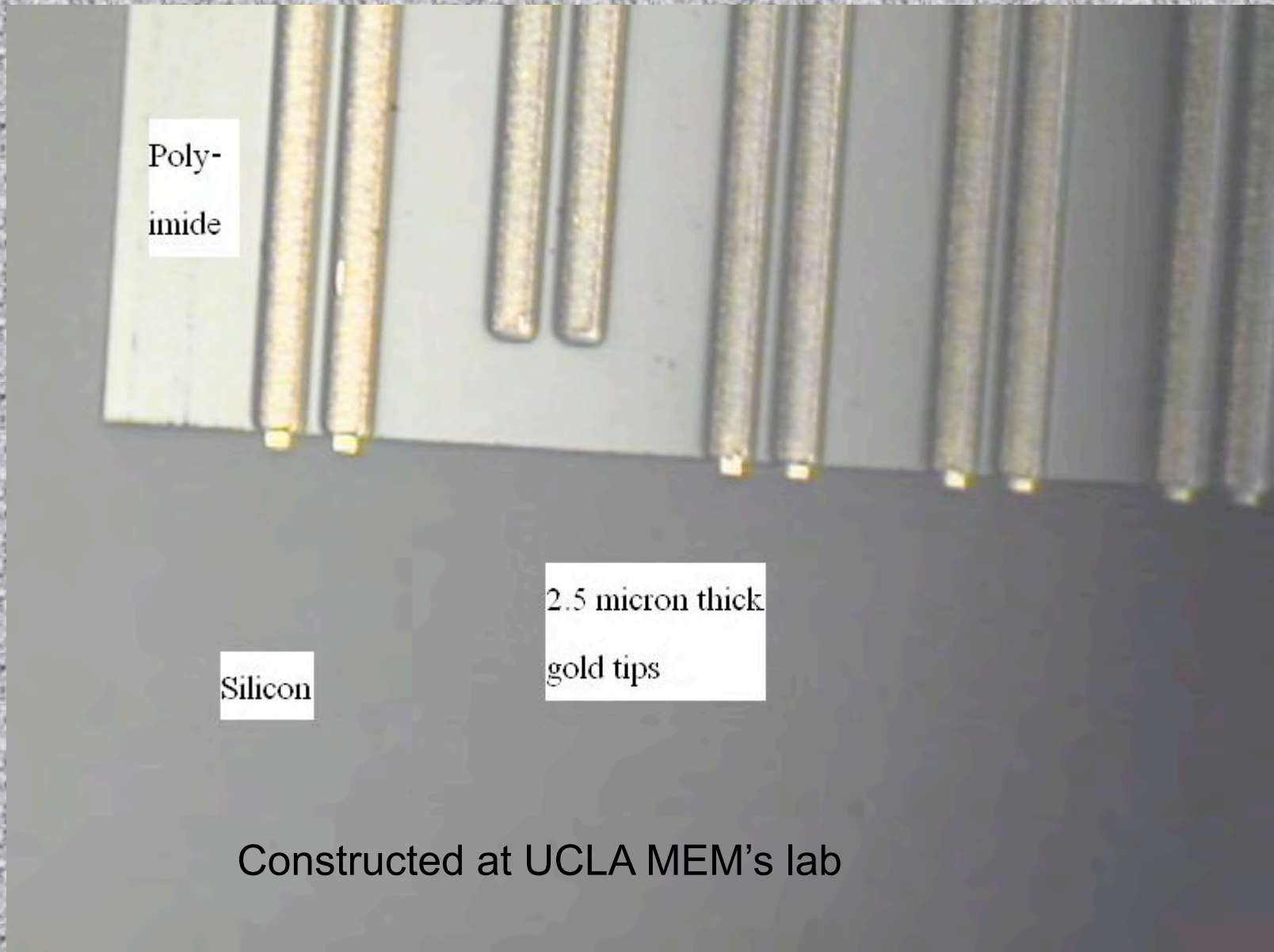
Challenge; They must be Debye  
scale in size

$$\lambda_D = \sqrt{\frac{KT_e}{4\pi ne^2}}$$

In space (auroral ionosphere)  $\lambda_D$  is  
1-10 m

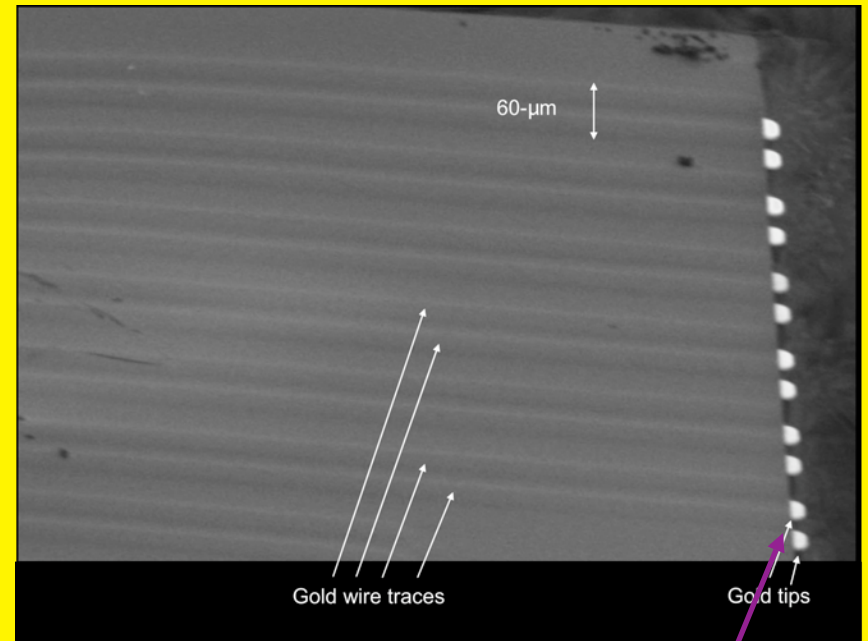
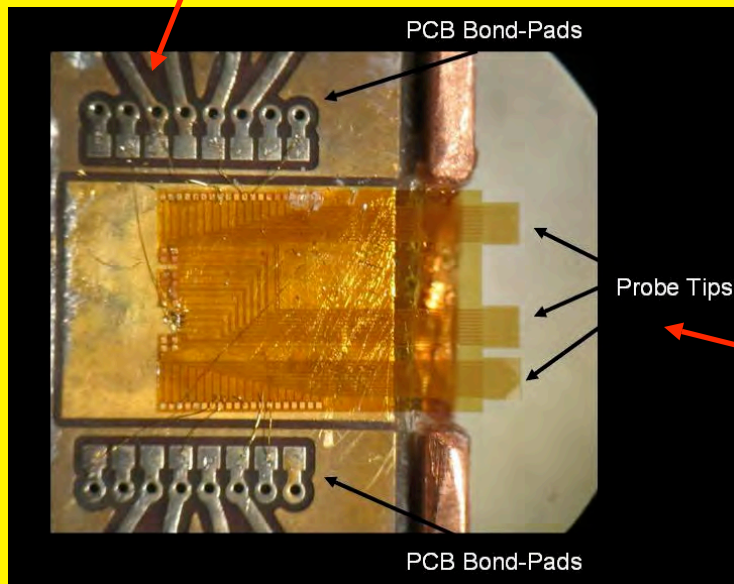
In LAPD  $\lambda_D$  is 30 microns

# E Field Probe: $-\nabla\Phi$



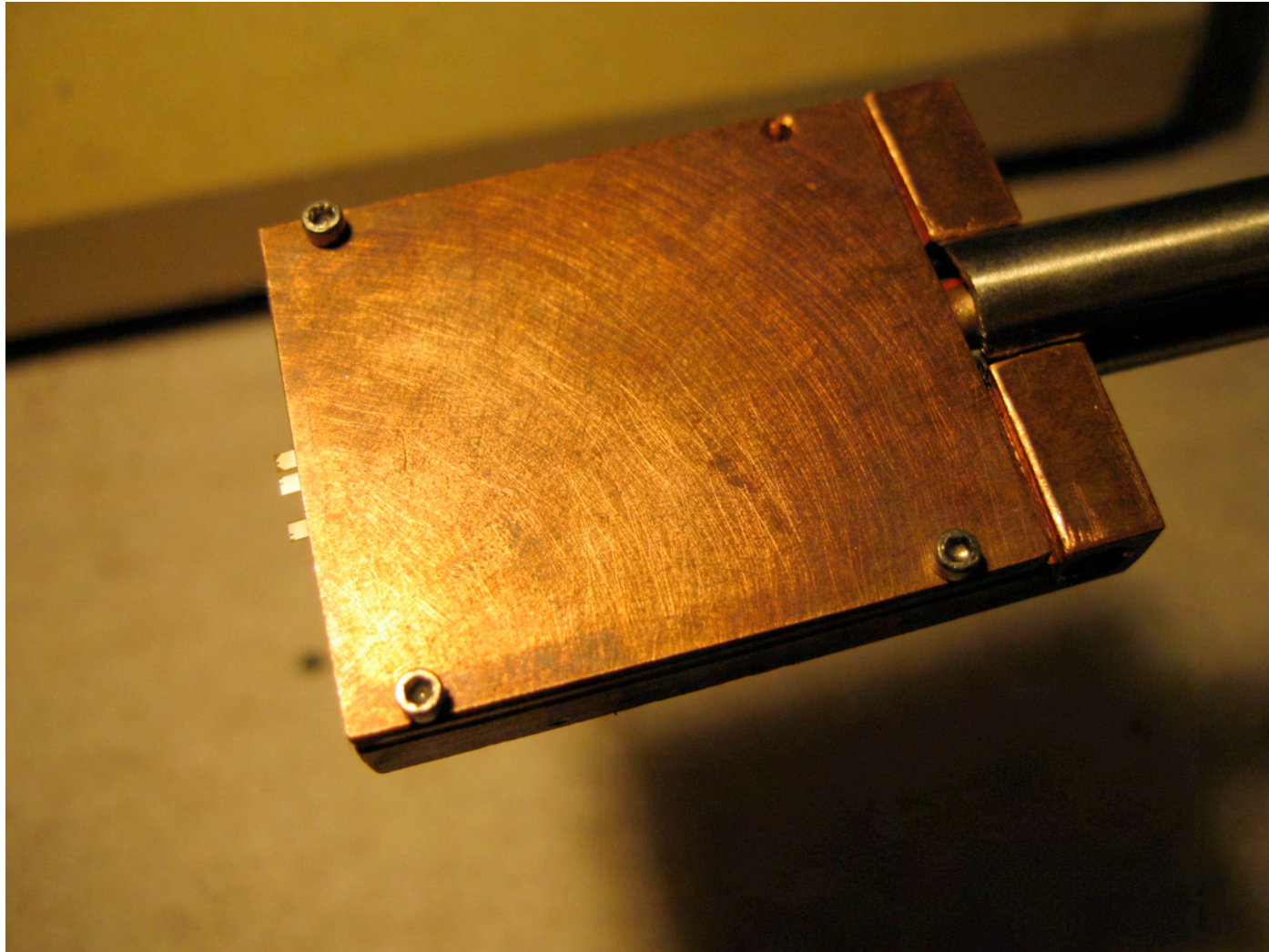
# E Field Probe

Bond Pads



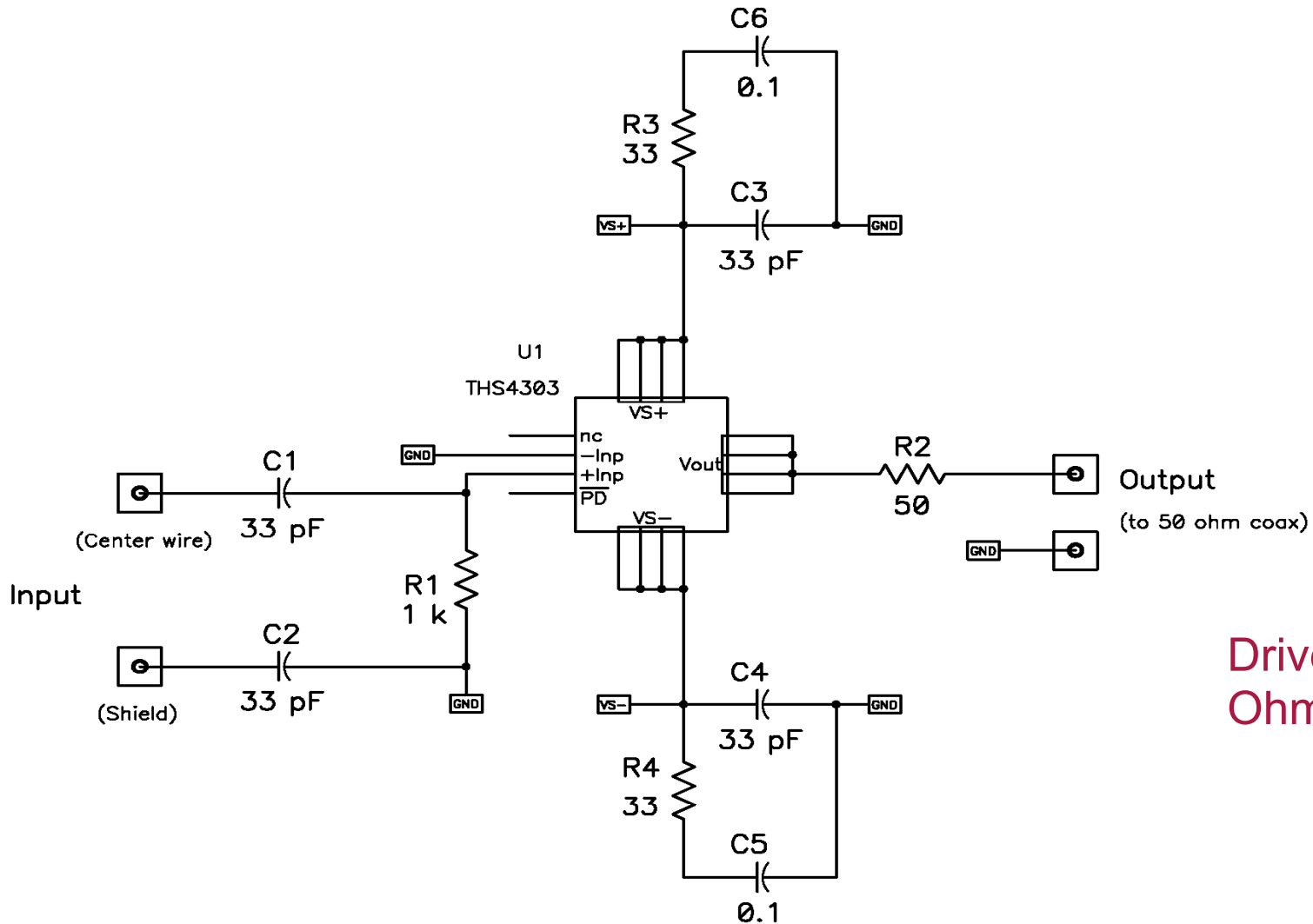
Probe Tips

# E probe and air-cooled circuit box

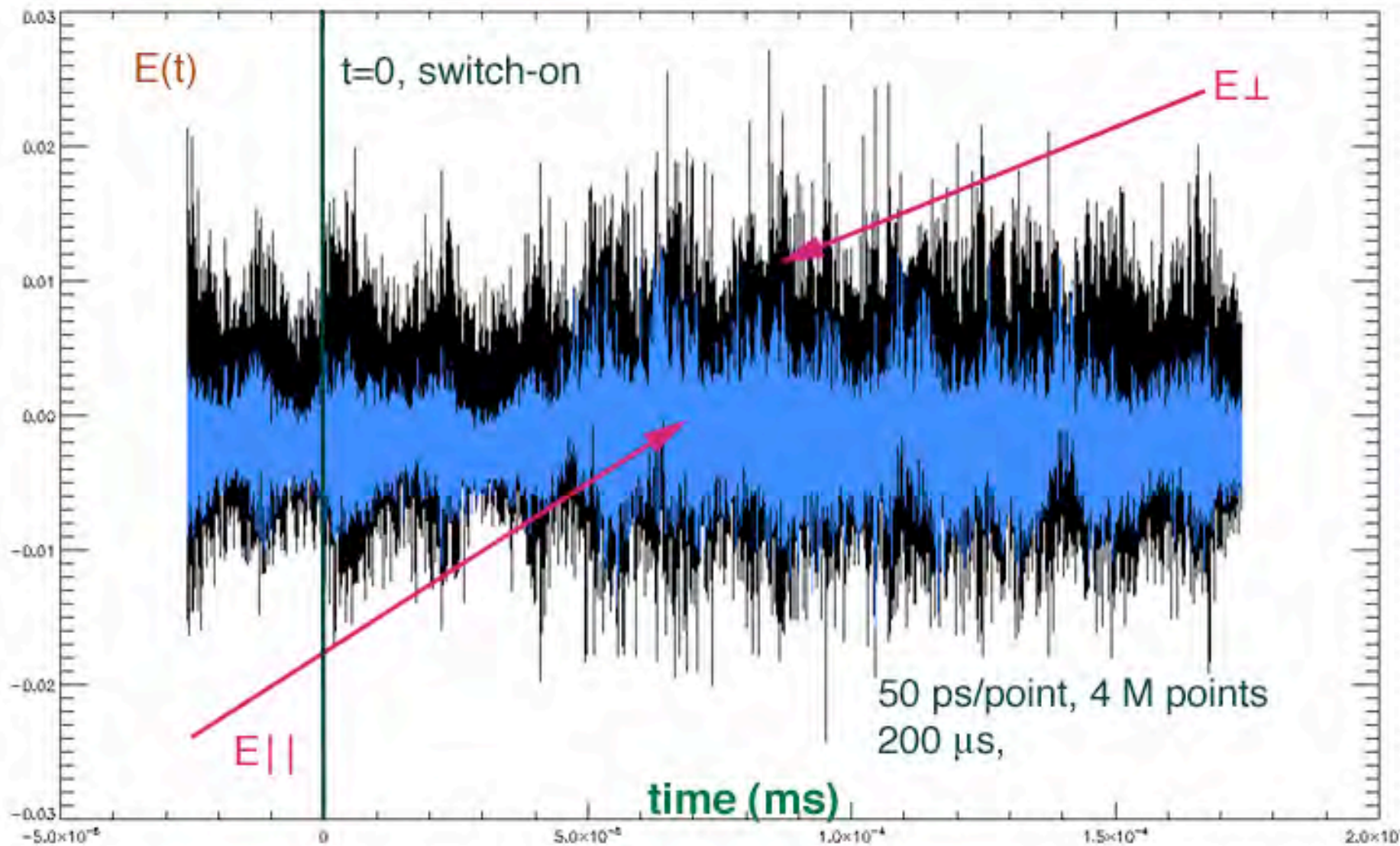


# Circuit diagram (1 probe)

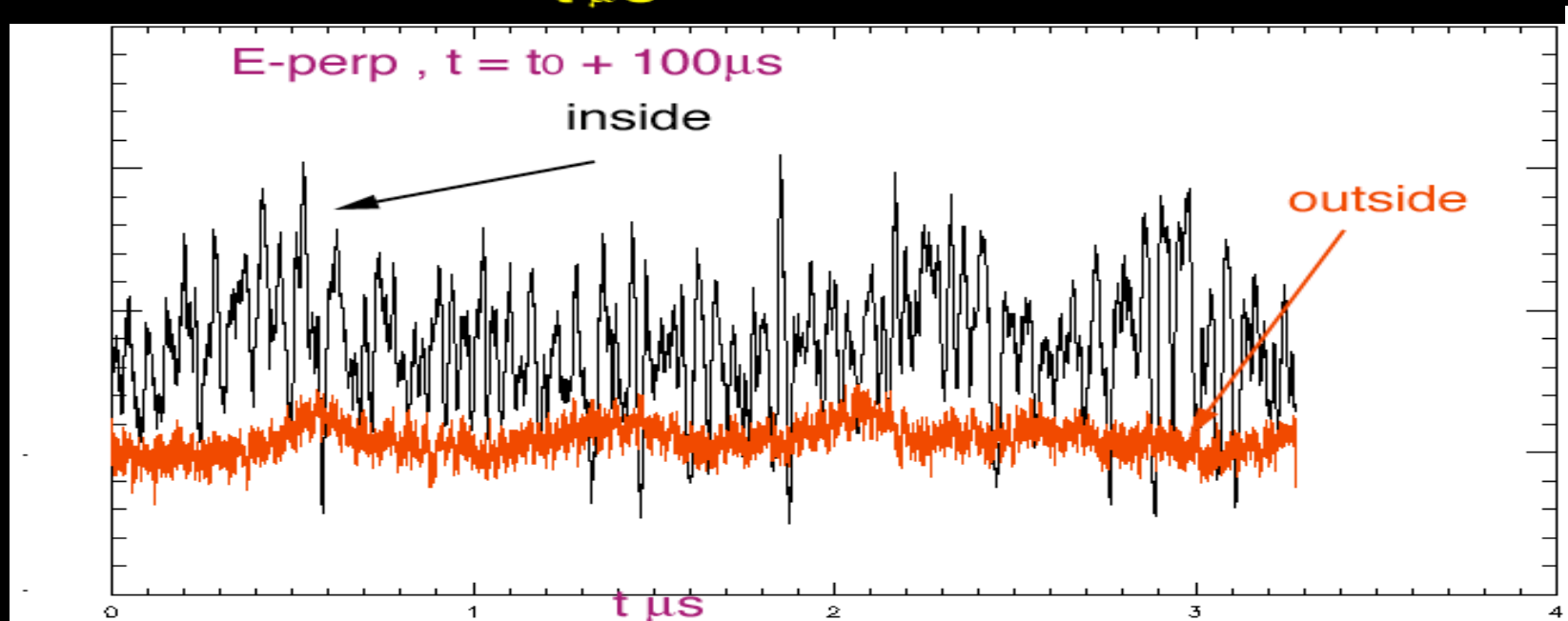
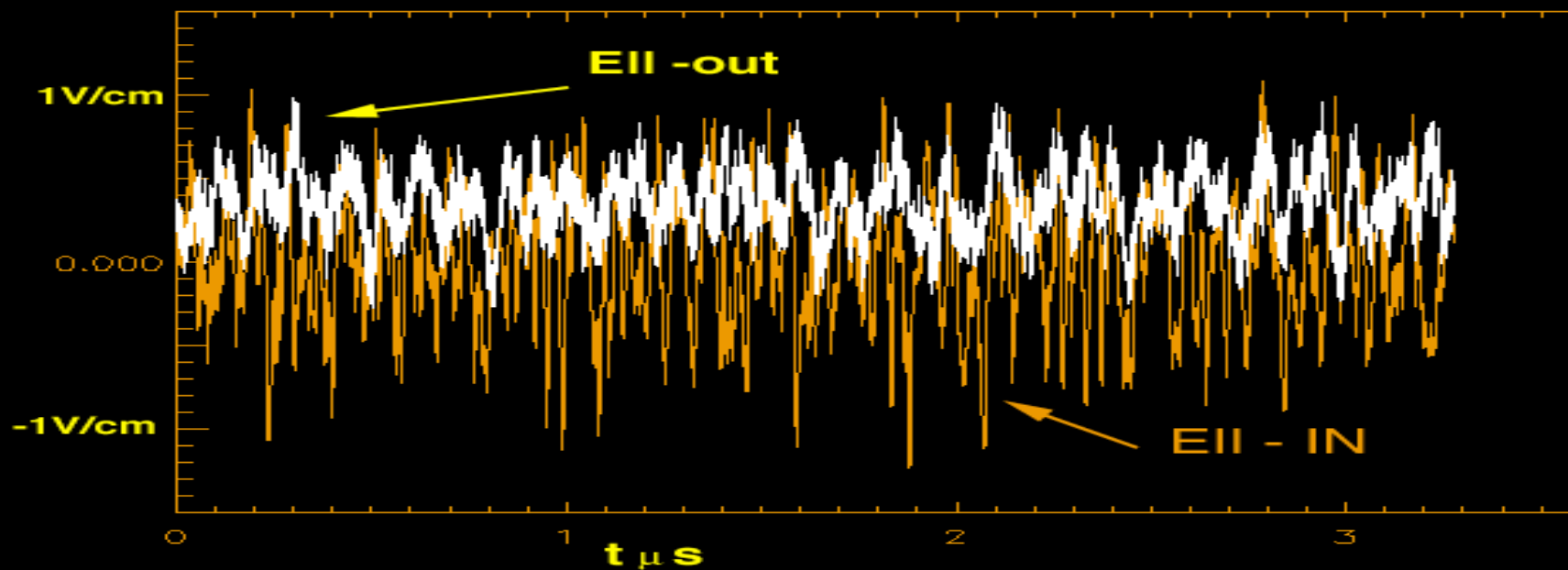
AMPLIFIER  
5 MHz – 1.8 GHz



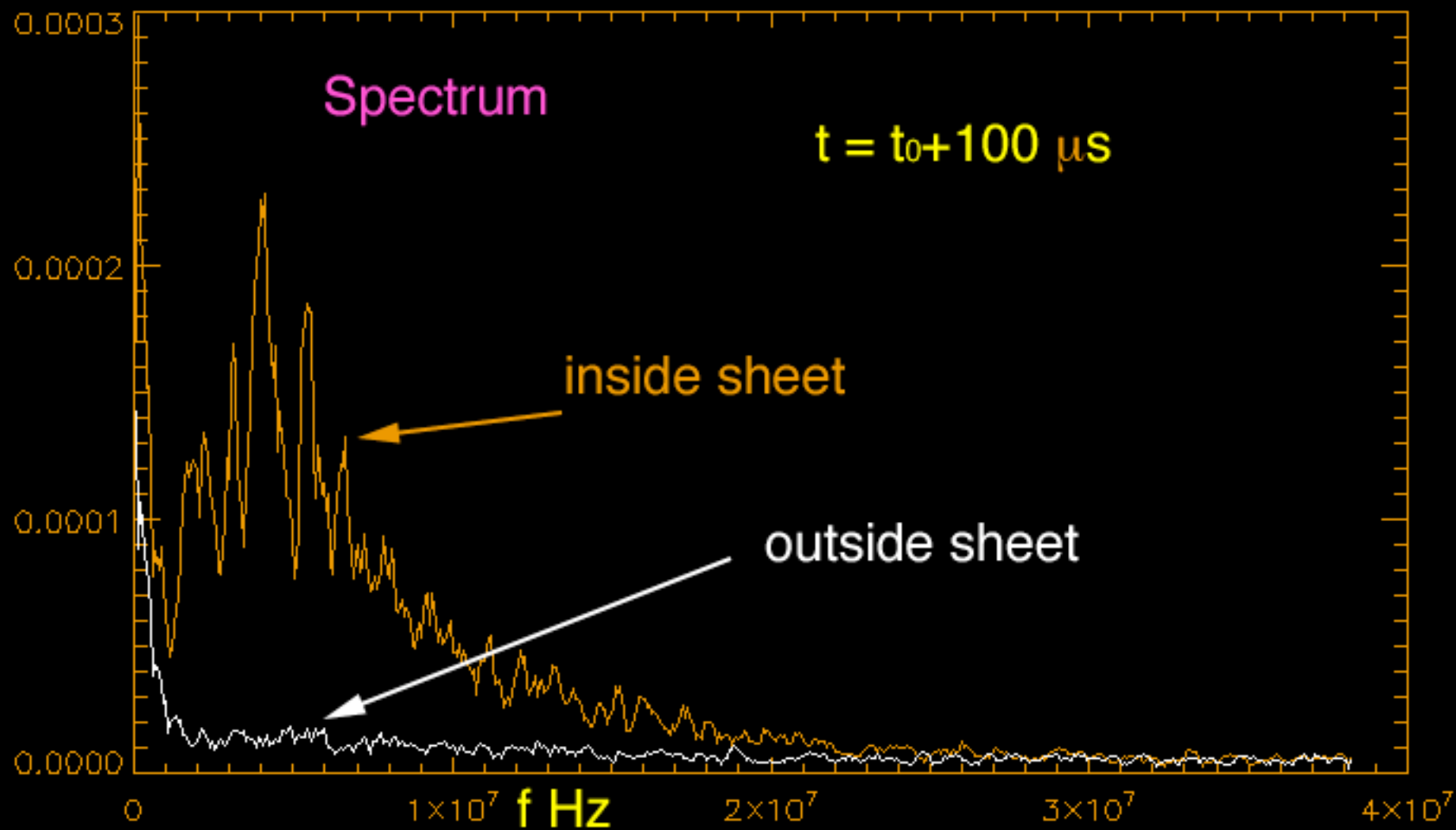
# Electric field in current channel



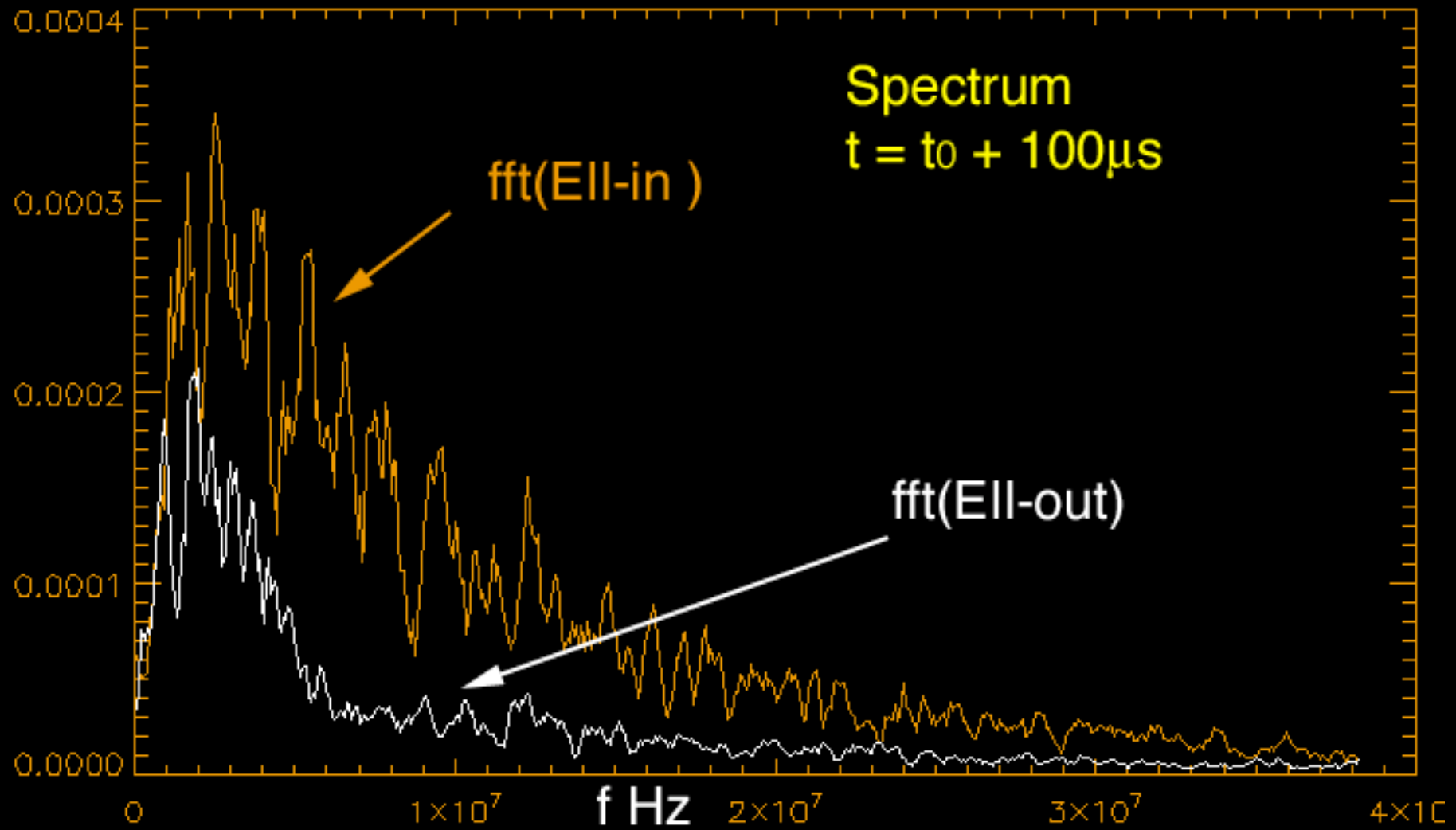
# Field Components



# Spectra $E_{\text{perp}}$



# Spectra $E_{\text{parallel}}$



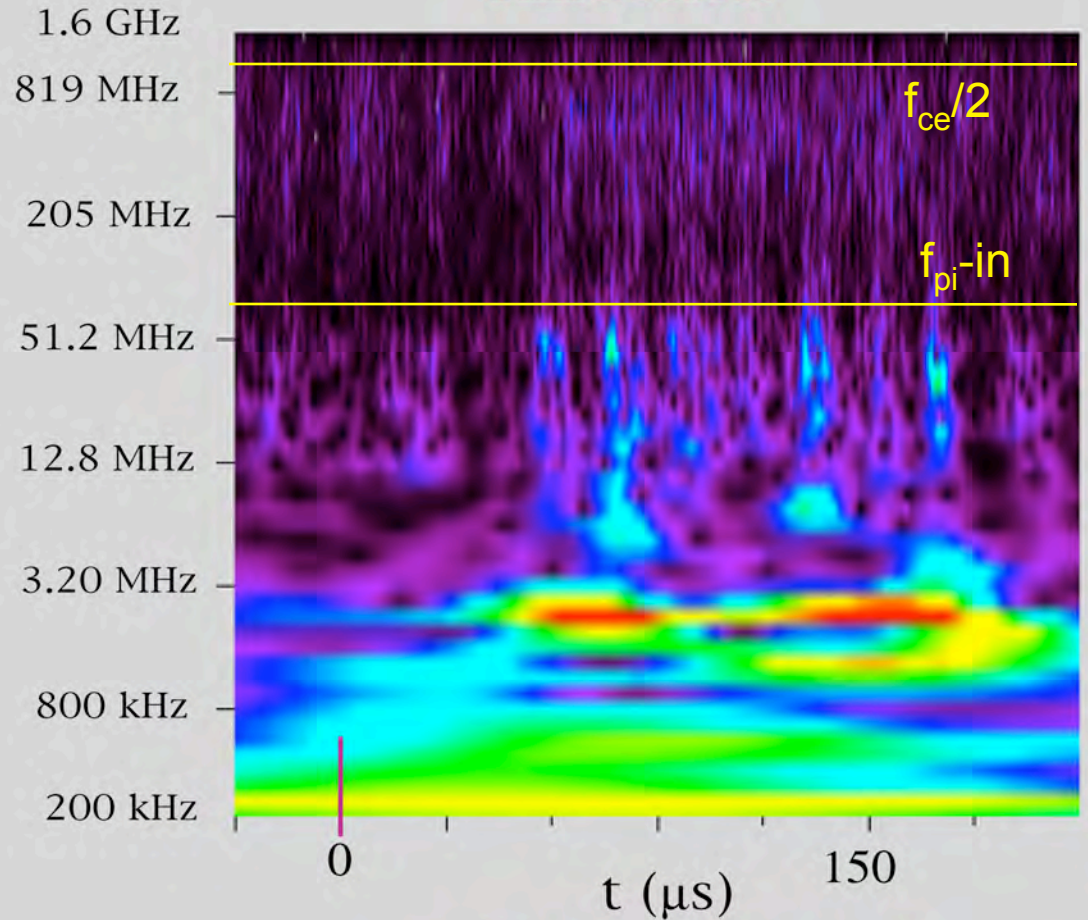
# Wavelet Analysis

E

Perpendicular  
to  
Background  
Magnetic  
Field



Time series

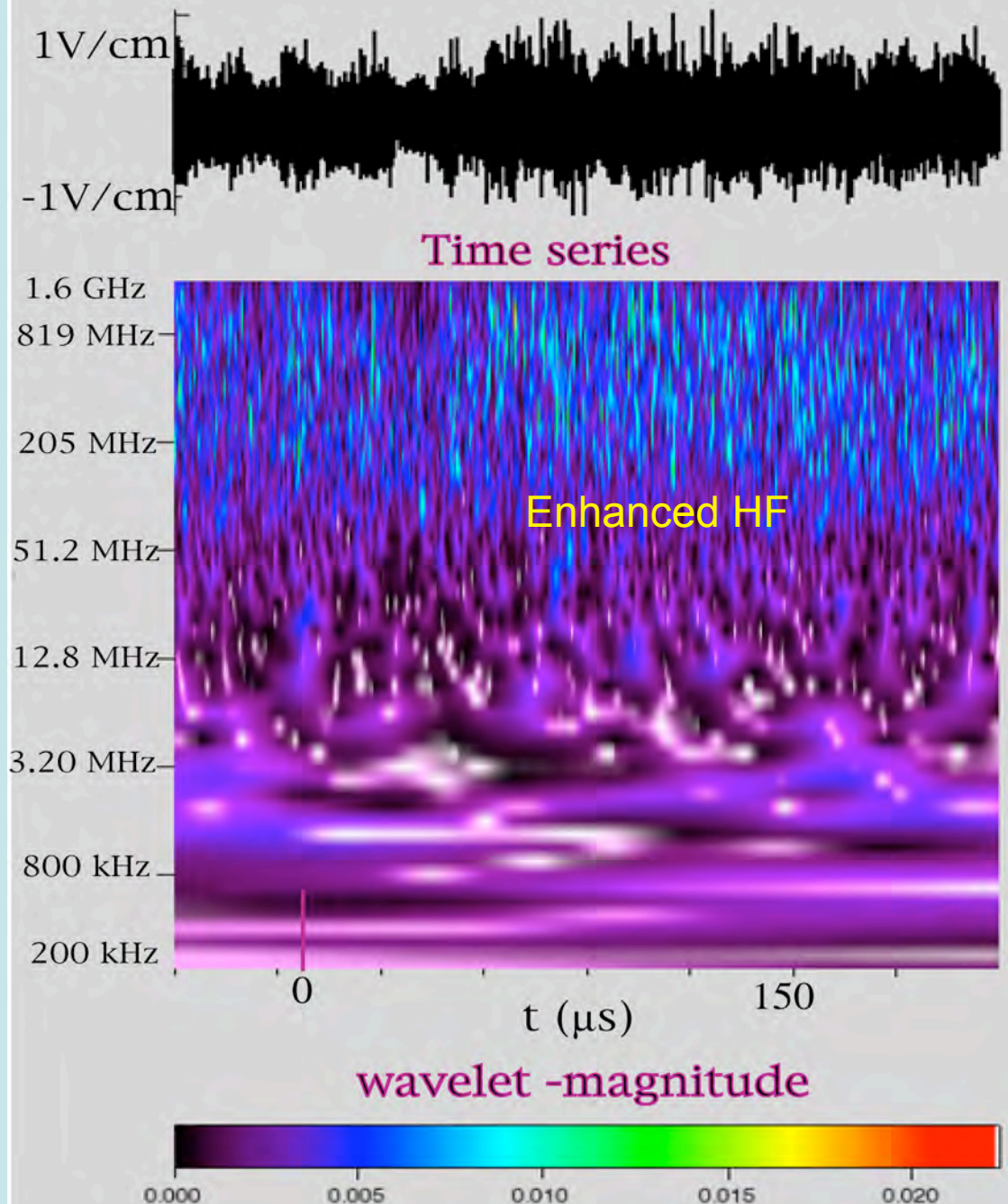


wavelet -magnitude

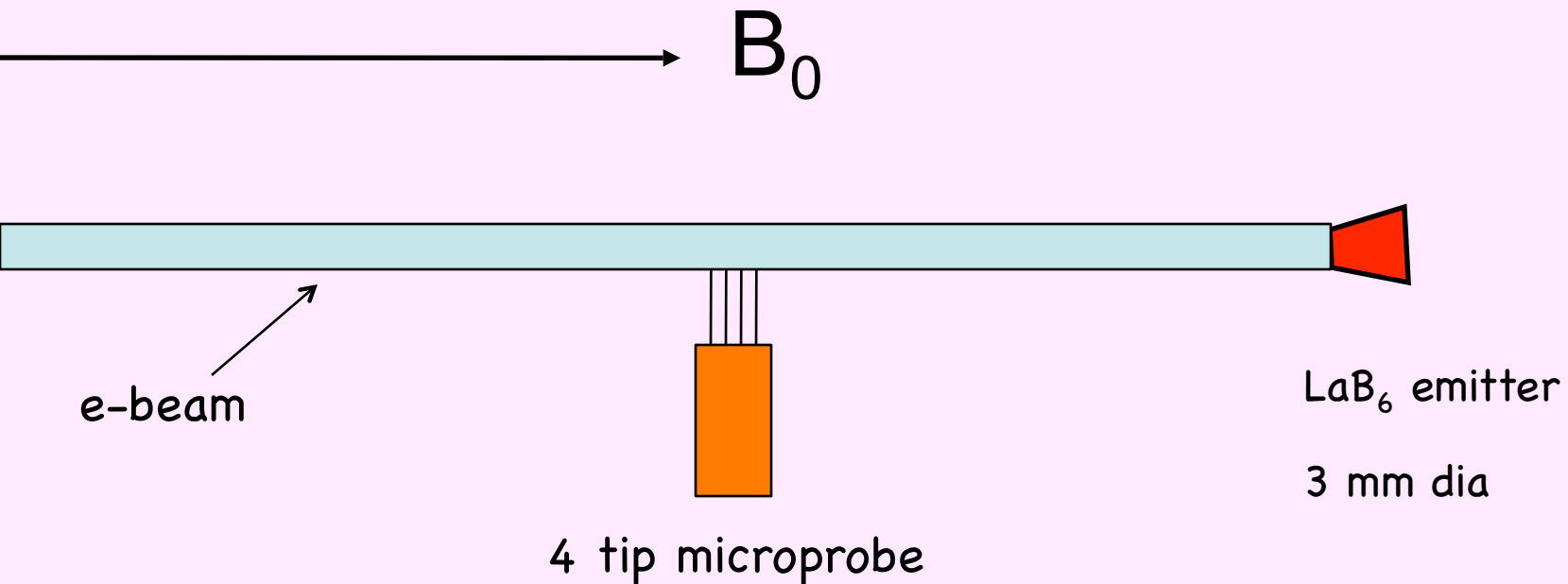
0.00 0.01 0.02 0.03

# Wavelet Analysis

E Parallel to  
Background  
Magnetic  
Field



# Probe in electron beam (low density $<10^9 \text{ cm}^{-3}$ plasma)



**Background Plasma**

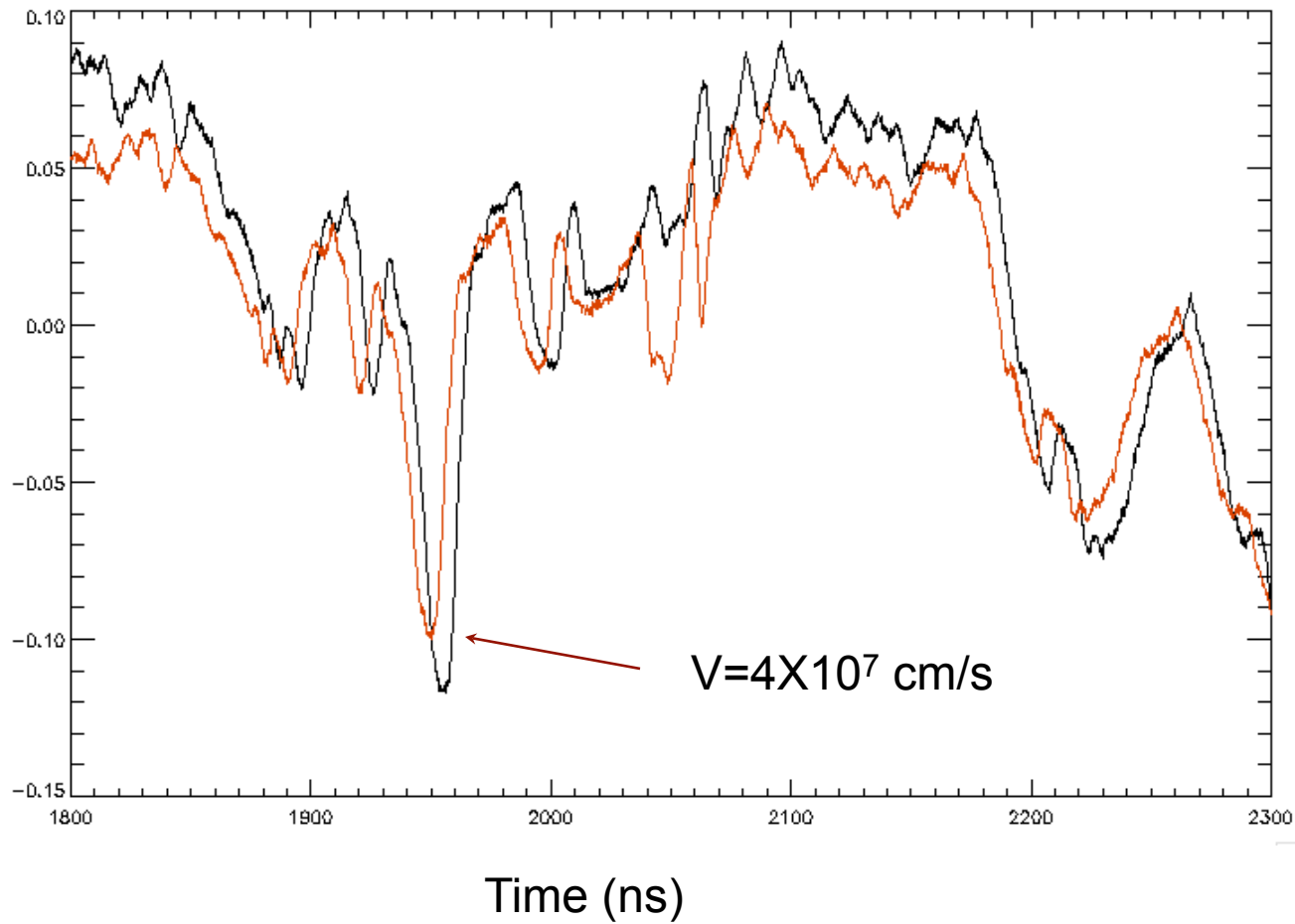
# Higher Frequencies- Langmuir Waves

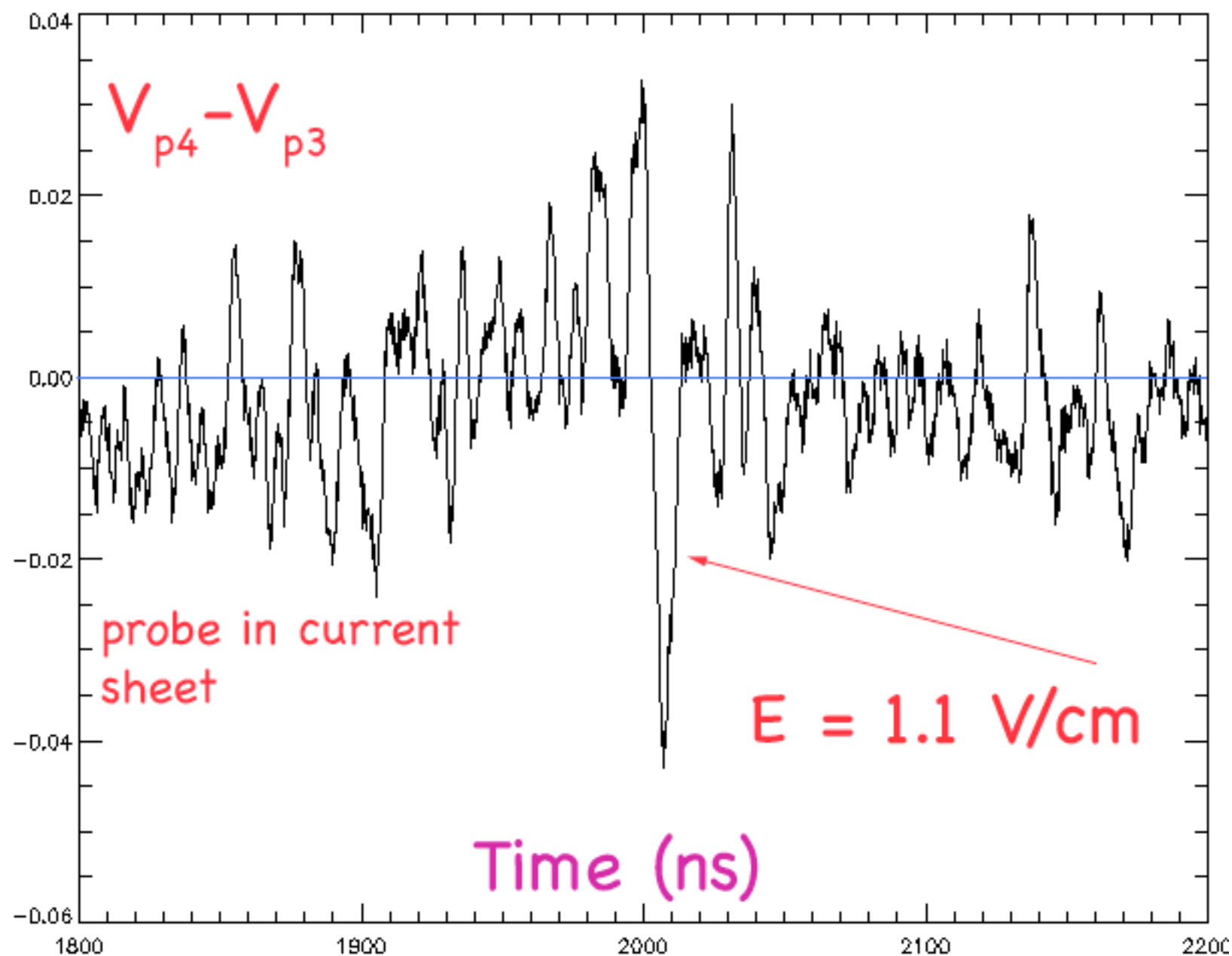
- The probe response was less than 2 GHz- in a separate experiment at lower density we searched for electron solitary structures.
- They are Debye scale size entities which move as fast as  $v_{te}$

# Spiky turbulence

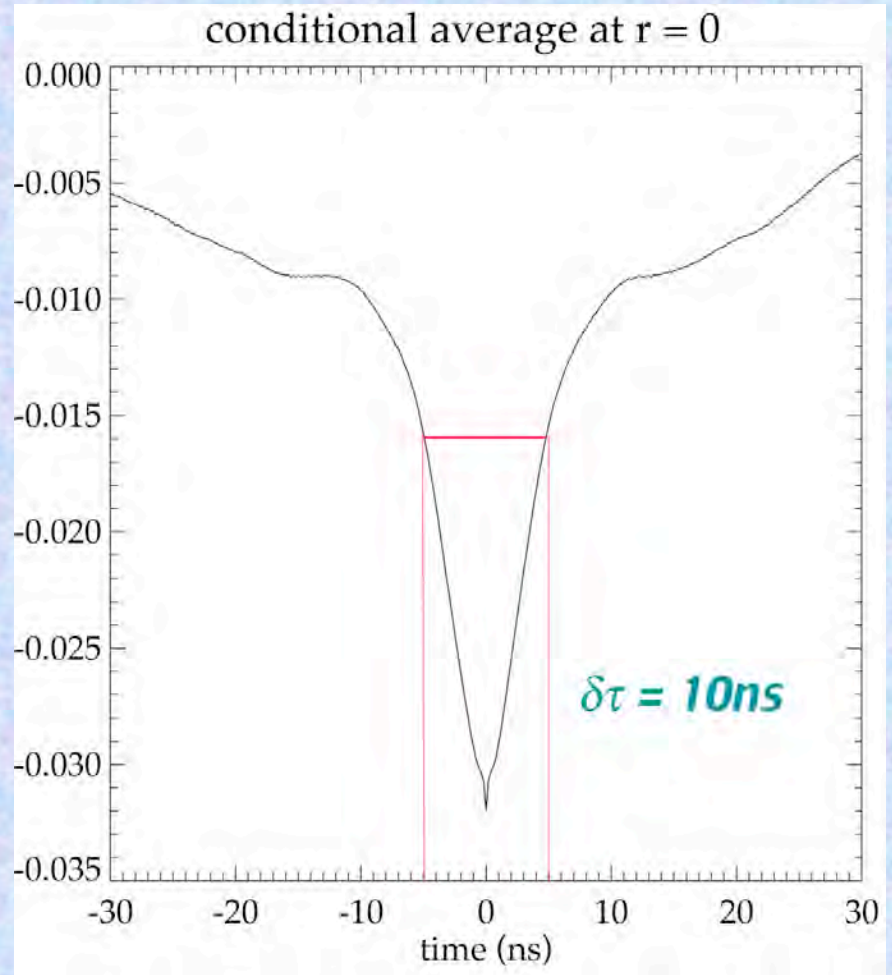
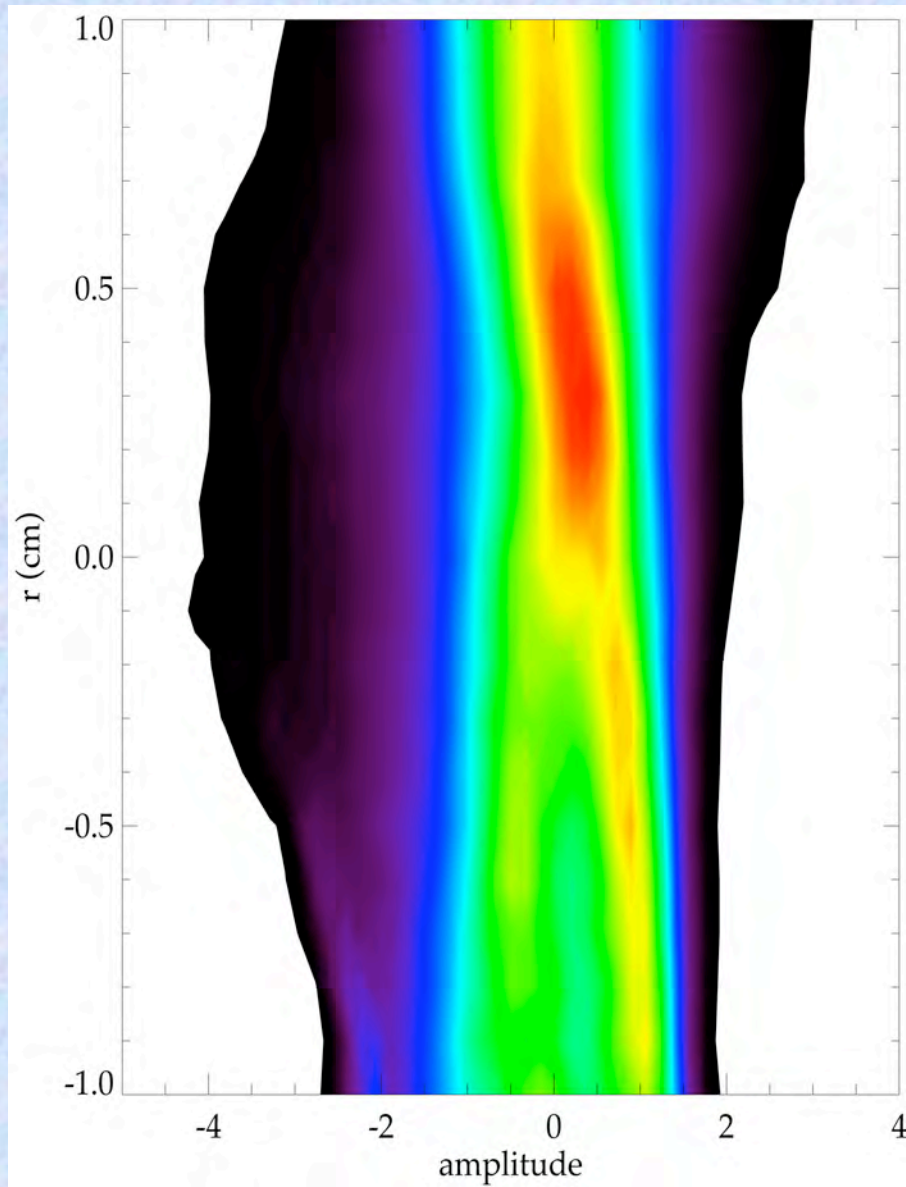
$$V_{\text{the}} = 1 \times 10^8 \text{ cm/s}$$

Voltage  
(Volts)





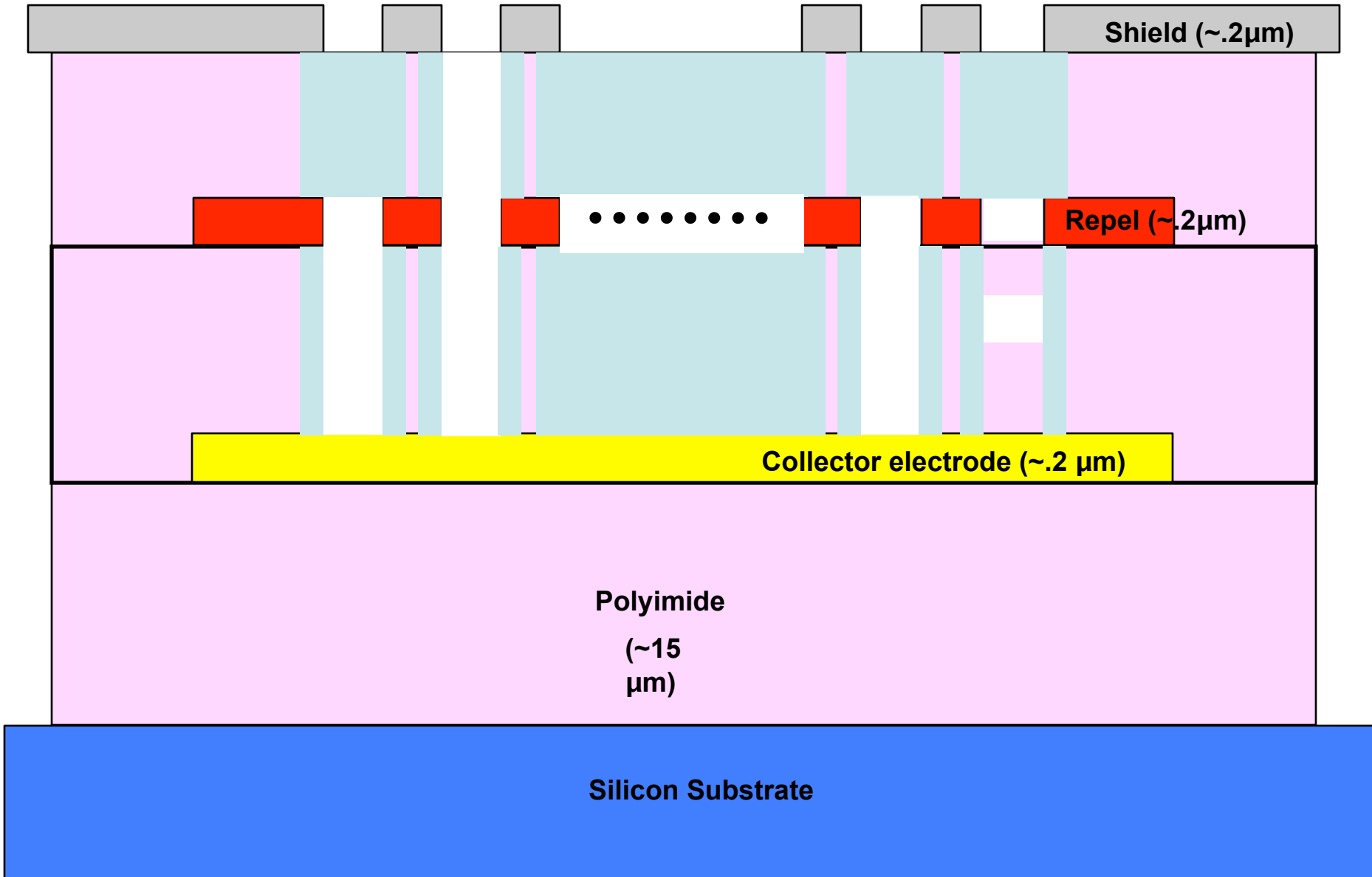
# Conditional Averaging



# Key issues raised in this experiment

- 1) Are low frequency phenomena (e.g. Drift Alfvén waves, flows) coupled to high frequency phenomena (lower hybrid, whistlers and Langmuir waves)?
- 2) What is the electron distribution function  $f(\mathbf{r}, \mathbf{v}, t)$  ?
- 3) What is the electron (high frequency) physics in a magnetoplasma?

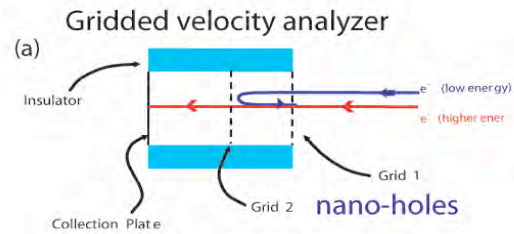
# Velocity Analyzer Grid Area (Cross Section)



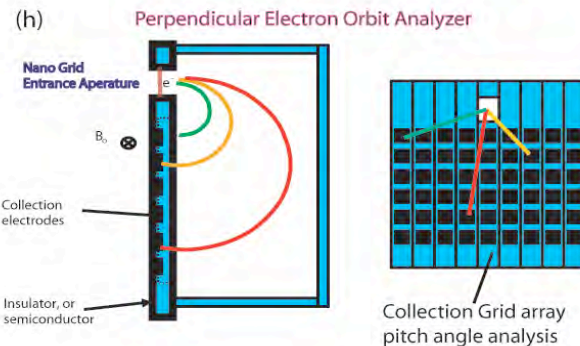
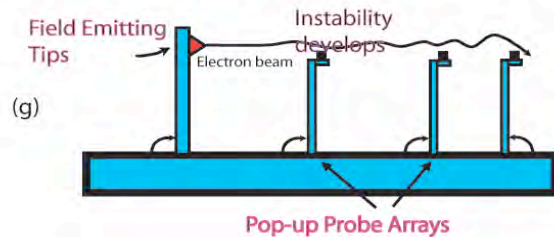
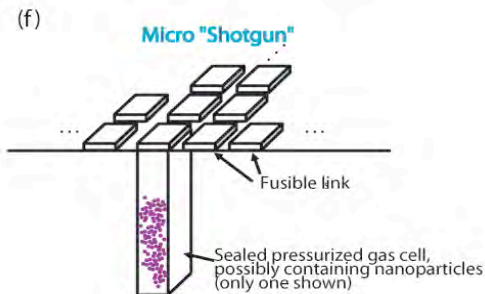
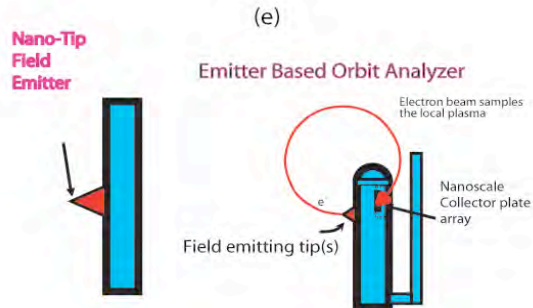
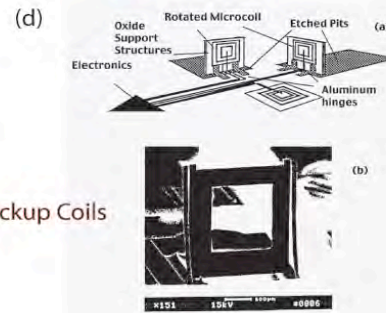
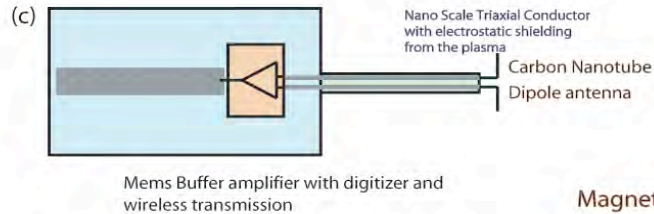
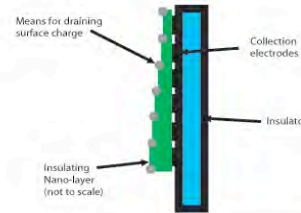
# Design Parameters

- Angle of Acceptance (desire less than 10 deg):
  - 2  $\mu\text{m}$  hole, total thickness 30  $\mu\text{m}$  à half angle = 3.82 deg
  - 2.5  $\mu\text{m}$  hole, total thickness 30  $\mu\text{m}$  à half angle = 4.76 deg
- Exposed area
  - 160x160 array of 4  $\mu\text{m}^2$  holes, 4  $\mu\text{m}$  between holes.
  - 1 mm x 1 mm head à 10.24% open area
- Current being carried
  - Expected current density: 1000 mA/cm<sup>2</sup> à 1x10<sup>-5</sup> mA/ $\mu\text{m}^2$
  - 160 \* 160 \* 4 \* 1E-5 = 1.024 mA (maximum collected)
- Gap closing force
  - For g = 15  $\mu\text{m}$  @ 25 V: F  $\approx$  10  $\mu\text{N}$

$$F = -\left(\frac{\epsilon_r \epsilon_o A V^2}{2g^2}\right)^{\frac{1}{2}}$$

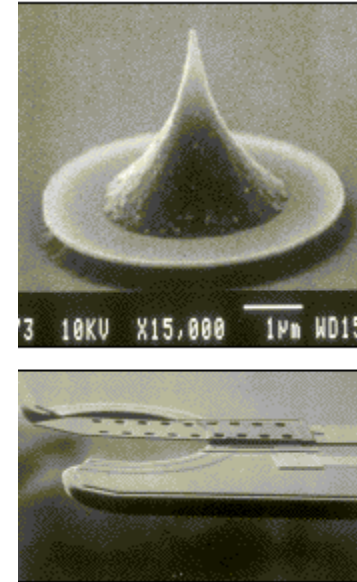
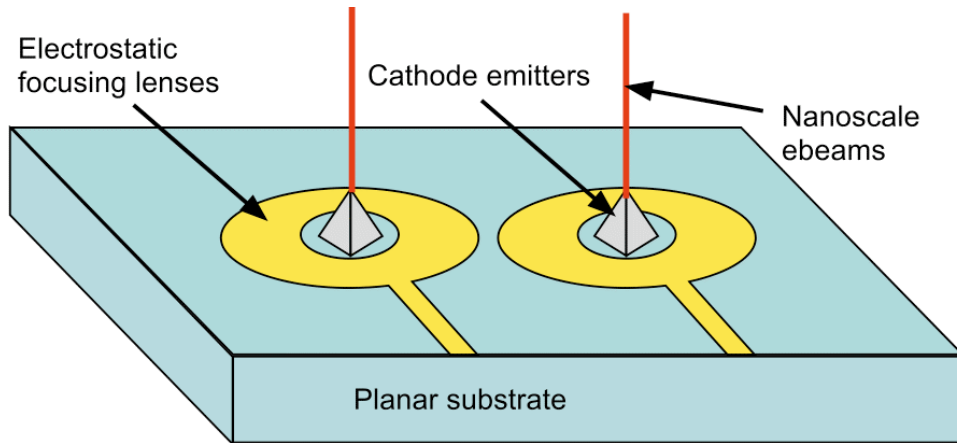


Quantum barrier E probe (b)

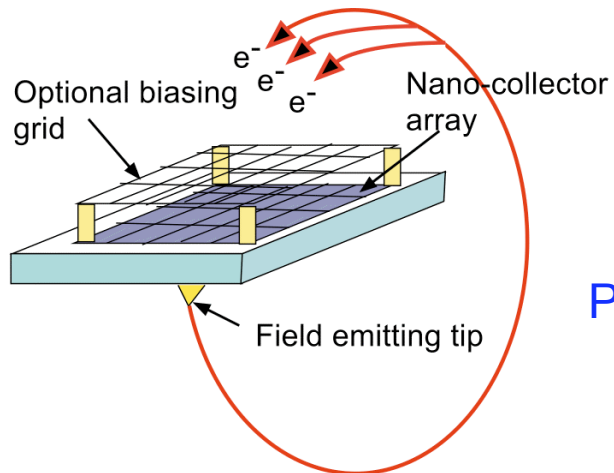


suggestions  
for other  
micronprobes

# Miniature e-beams



Emitter fabricated at Univ. of Michigan



Proposed orbit analyzer